Topic: HDMI® Cable Compatibility & Selection
Date: 22nd March 2011
Author: David Meyer, Founder & Product Development Director – Kordz Pty Ltd
Company - HDMI Adopter since 2005, CEDIA member, HDBaseT Alliance Adopter member
Personal - CEDIA Certified Instructor as SME on HDMI, ISF & HAA (I) certified dealer,
CEDIA Asia Pacific Board of Directors member 2009

Introduction

Every AV installer/integrator uses HDMI® every day, but we still continue to hear that many are frustrated at the inconsistency of distributed information, and just want to know which cable is best to use in a given installation. With the coming evolution of HD-3D & 4K video, you're now expected to install HDMI cables that will support formats for which you can't yet even test. That is, you put it in now and just hope that it will work later, basing your decision on information supplied by the vendor, or published in cable comparison charts. What are the key indicators to assure compatibility and longevity? Let's take a look...

HDMI cable feature, speed & length dynamics

Web &/or print publications have at times made efforts to put together HDMI cable buyers' guides of sorts, in an effort to assist the trade in comparing market available models with a perceived degree of independence. The intentions of such initiatives are noble in principle, but may be based on nothing more than unqualified vendor surveys. For example, such publications may;

- infer an unrealistic availability of High Speed HDMI cables, as they don't qualify speed capability at each available length
- list model bandwidth (MHz) or data rate (Gbps), again without referencing length variability
- list video resolution, frame rate and color depth capabilities, without expressing their co-existence capability in a given cable **** see Fig 1 below***
- infer such feature support as 3D and Audio Return Channel as being determined by the cable, which it fundamentally isn't. Cable quality & length may hinder performance in many examples, but they are still fundamentally features as determined by the devices, not the cables
- list HDMI ATC certification by version number, without verification or reference to actual HDMI CTS (Compliance Test Specification), and with no onus of proof
- imply that there is such a thing as audio certification for cables, such as from Dolby Laboratories or DTS, which there isn't. Also, ALL HDMI cables fundamentally support ALL specified audio formats, regardless of so-called 'version' or cable vintage

Fig 1 – Hypothetical extract from an HDMI cable guide

Bandwidth	Video Resolution	Frame Rate	Color Depth
10.2Gbps	1080p	120Hz	48 bit

A given cable may well support any of the above formats, but not necessarily concurrently. The above example, however theoretical in application, combines to a whopping **17.8Gbps** - well beyond 10.2Gbps High Speed HDMI. This is realistically only possible in a handful of high quality, very short length cables on the market. Some vendors have even listed nonsense like 400Hz capability. An HDTV may process to this internally, but that's got nothing to do with what's going through the HDMI cable!

Unless such details are disclosed and individual lengths and capabilities referenced, such initiatives still don't help you to reliably choose an HDMI cable. Conversely it only adds confusion and frustration when the cable may later fail through inadequacy. This is why we at Kordz are yet to participate in any such publication, even where it may present a free marketing opportunity. We prefer instead to defend our integrity and counsel on exactly what can be expected from each and every model and length that we supply, for best installation compatibility and longevity. Following are the real points of concern, with an overview guide for each.

HDMI Cable Speed & Headroom

There's two ways to speed rate an HDMI cable – 1. HDMI ATC (Authorised Test Center), and 2. Capable data rate limit in use. Most people are fully aware now that there are just two defined official 'speeds' of HDMI cables in the specification – *Standard* (2.23Gbps) and *High Speed* (10.2Gbps). Neither of these numbers represents a magic cliff, whereby the data rate disappears above the defined number. Conversely, each is actually a defined **minimum**, not maximum. HDMI ATC certification is only concerned with these two compliance levels, with compliance further determined by things like specified capacitance limits across various pin pairs, resistance levels, skew causing insertion loss & jitter (measured with eye diagram) and even details like connector dimensions, amongst other things.

In actual fact, a *Standard* certified cable would in application support a data rate range of somewhere between the minimum 2.23Gbps to less than 10.2Gbps, whereas *High Speed* would be 10.2Gbps or greater, with no defined upper limit. For example, an HDMI cable may be able to support, at best, up to 1080p60 in application. At 4.455Gbps, this is still nowhere near the *High Speed* minimum of 10.2Gbps, so the cable is labelled *Standard*. To put it into perspective, the data rate of 1080p60 is just over **one quarter** of the way between *Standard* and *High Speed*, so clearly High Speed HDMI is not to be taken for granted.

HDMI Cable Length

This is getting to the core of my point (excusing the pun). Unavoidable laws of physics apply to all cables, and things like capacitance, resistance and skew all degrade the signal within. Putting it bluntly, a good cable simply screws up the signal less than an ordinary one. Capacitance is linear, wherein all other things being equal, a 10m cable should exhibit ten times the capacitance of a 1m example. Similar for resistance, which is so predictable and consistent it can be calculated based on conductor material and gauge (thickness).

Let's look at a hypothetical example of maximum data rate for different lengths of high quality HDMI cable. This is not based on any existing model, rather an illustration of the length vs headroom dynamic;

- **1m** – may potentially show an operable eye pattern to 22Gbps. Labelled **High Speed**
- **2m** – has double the Resistance (R) and Capacitance (C) of 1m, as well as greater intra-pair and inter-pair skew, increasing insertion loss and therefore reducing the max data rate (headroom) to 18Gbps. Labelled **High Speed**
- **3m** – has 50% more R, C & skew than the 2m, exponentially reducing the data rate to around 12Gbps. Labelled **High Speed**
- **5m** – would drop well below the High Speed data rate of 10.2Gbps, so thicker gauge is used to reduce insertion loss and produce a data rate of *just* beyond 10.2Gbps. Labelled **High Speed**
- **10m** – Cable gauge max'd out to practical limit of 24AWG in an effort to overcome significant insertion losses. Even so, max data rate can only be achieved to say, 8Gbps. Plenty of headroom for good 1080p60 operation, but still only labelled **Standard** as it's less than 10.2Gbps
- **15m** – Max data rate measured to 6Gbps, also 1080p60 supporting. Labelled **Standard**
- **20m** – Max data of 4Gbps, so not assured for 1080p60, but still over 2.22Gbps. Labelled **Standard**

This length range example assumes that each cable still passes the other stringent tests of ATC to ensure product compliance. If they don't then they are deemed non-compliant and can't legally bear the Standard or High Speed labels, or even be sold in the market for that matter!

One of the most common practices that we witness is the phenomenon of quoting a particular cable model as *High Speed* HDMI, then go on to say "available in 1-20m lengths", or similar. As the example above shows, every length is different in characteristic, even in the same brand and model/series. To represent all lengths in a given series based on its shortest length speed label is uninformative and, frankly, misleading. This is especially so if the longer lengths have no technological advancement other than being thicker gauge, as even the best passive HDMI cables in the world are not High Speed beyond around 10m. Fact is that we won't really be able to house test the true capability of so-called High Speed cables until we get to use them with formats like 1080p60-3D (aka 120Hz) or XHD 4K video, but that's some way off.

I don't mean to sound too cynical, but it's much easier to write *High Speed* on a cable than it is to make one. It certainly adds marketing muscle, after all, as who goes out of their way for "Standard"? Be aware that *every length* differs in maximum data rate capability and hence potential format and feature support. I think I've hammered that point sufficiently, so now I'd like to take a closer look specifically at certifications, individual features and some other common misconceptions.

Video Format & Resolution Support

Let's just get right down to what every installer has wanted to know to date – will a cable support 1080p60? The good news is that nothing has really changed in the last few years other than the new mandatory cable labels. If a cable claims to support 1080p60, and you've tried it and proven that it does, then in application it actually doesn't matter whether it claims to be Standard or High Speed HDMI. However if you're looking for future support for higher end formats, then genuine High Speed is essential. As for frame or refresh rate, this is simply a matter of arithmetic. 1080p60 @ normal color depth (8 bit/channel) produces a data rate of 4.455Gbps. 120Hz is double this at 8.91Gbps, and 30Hz is half 720p-2D!

Every Kordz HDMI cable model and length is made to support 1080p60-2D and 1080p24-3D as a minimum. If we can't engineer it to support these formats, we simply don't make it.

3D Support

Nothing has changed inside the HDMI cable to enable 3D support, contrary to popular belief. 3D relies on a sufficient data rate capability to support the desired 3D formats, per simple arithmetic as mentioned above. For example, 1080p60-3D frame alternate is effectively 1080p120, being 60 frames for left eye, and 60 frames for right eye. So the data rate for 120Hz is double that of 60Hz, hence 4.455Gbps x2 = 8.91Gbps. The maximum mandatory 3D format for Blu-ray right now is 1080p24-3D, being effectively 48Hz. It's simple maths – 1080p24-3D calculates to (4.455/60)x48 = 3.56Gbps approx.

Interestingly, we've anecdotally learned that actual cable quality can influence 3D operation as well, but this has nothing to do with cable generation or version. We suspect this comes down to the DDC channel for accurate delivery of the 3D 'flag' in the EDID, so a good quality cable is essential. Even an old Kordz *Krystal* or *Diamond* series HDMI cable from 2006 will support 3D, tested and proven in the field to lengths beyond 10m. Any quality cable that already supports 1080p60-2D should be fine for all mandated 3D formats. However when 3D inevitably evolves to 1080p60-3D, particularly for gaming, then the data rate goes to 8.92Gbps, so genuine High Speed is essential.

Audio Formats & Certifications

All HDMI cables support all included audio formats, including HD Audio. There is no such thing as HDMI certification for audio formats, and a simple rule is that if an HDMI cable has been known to NOT support any particular audio formats, simply stay clear of it. For the record, audio performance can and does vary in HDMI cables, but only with PCM and HD audio formats. Common 5.1 compressed Dolby Digital and DTS formats cannot vary as they are packeted digital streams - either they work or they don't. However other formats which rely on analogue sampling frequencies (PCM & HD audio) do certainly vary in performance, so your choice of HDMI cable can impact on the system's overall audio performance.

HDMI Ethernet Channel

HDMI Ethernet Channel is the only new physical feature in HDMI cables, but to date is still virtually unused in devices. This is not to say that you shouldn't bother with HDMI Ethernet Channel, but just be aware that acquiring this feature would only be for future application. For compatibility, simply look out for cables labelled 'with Ethernet'. To be compliant, an HDMI cable does not just simply require the physical presence of the extra twisted pair. Rather the CTS specifies a maximum capacitance level of 700pF measured across a cable's various pin pairs in the HDMI Ethernet Channel, regardless of cable length. As capacitance is a linear distance phenomenon, this maximum specification makes compliance increasingly difficult at longer lengths, but is generally achievable to around 12m in a quality example.

Audio Return Channel

The Audio Return Channel (ARC) is an interesting and appealing new feature of HDMI, permitting upstream transmission of SPDIF supported audio formats from HDTV to an AVR through the HDMI cable, instead of via TOSlink. There are two modes of ARC – *Common Mode* & *Single Mode*. Common Mode uses the new twisted pair of the HDMI Ethernet Channel, whereas Single Mode uses a single utility wire which was already present in all HDMI cables, ensuring backwards compatibility. The mode used is determined by the devices connected, but Single Mode remains significantly more prevalent.

We've received reports from some installers that have used cables *without* Ethernet Channel and ARC does not work, then switch to a cable *with* Ethernet Channel, and ARC kicks into life. This may logically suggest the support of HDMI Ethernet Channel in the devices, and Common Mode ARC, but the more likely scenario is that the utility wire gauge is different between cables used. Historically, long HDMI cables which may have thick 24AWG TMDS pairs may only have a thin 30AWG utility wire, wherein the ARC may simply fail through attenuation. Switch to a cable with Ethernet Channel and the same wire is now thicker, so ARC starts to work. It's not the ARC mode that determines operability, rather just wire thickness.

Bottom line – most existing HDMI cables will support Single Mode ARC, the only exception being many longer length models in which the resistance on a relatively small utility line may mean that the ARC does not go the distance. Lengths to 5m should all work fine, and up to 10m or so by trial. A thicker relevant utility wire in a more modern cable, regardless of the presence or lack of HDMI Ethernet Channel, may enable Audio Return Channel to work over longer lengths. To enable Common Mode ARC where supported, use an HDMI cable labelled "..*with Ethernet*".

HDMI versions

HDMI version numbers can no longer be referenced with HDMI cables, and rightly so. Version numbers have actually never been relevant in identifying feature and format support in cables, as the only real physical change in a cable (other than vendor specific technology, developments and termination techniques etc) is the HDMI Ethernet Channel. To make my point, even the earliest Kordz *black series* cable that we released

way back in 2005 will support HD Audio, 3D, and particularly in shorter lengths, even Audio Return Channel and 4K video!

Conclusion

In any installation, the cable should be the easy bit, but the challenge for you is that you're now installing for formats that you can't yet even test for, such as HD-3D and 4K video. You're the one that gets the call later on if the cable you installed fails to work when a customer upgrades some devices where compatibility was assumed.

To help you choose and install the right cable NOW for future compatibility, it is imperative for you to focus less on features (which are mostly device based anyway) and instead understand the inverse relationship between cable length and data rate. Longer cable = higher insertion loss = lower data rate. Higher quality cables generally yield lower relative losses and therefore go longer distance. They also produce more reliable, longer term results and even a degree of 'future proofing'.

Trust in your choice of cable vendor for honest and transparent cable labelling at each incremental cable length, then choose Standard (with 1080p support) or High Speed, with or without Ethernet as desired.

Kordz Education

Kordz has been an HDMI Adopter since 2005, with two of our Directors being CEDIA Certified Instructors as Subject Matter Experts (SME) on HDMI. Application of this role has extended to presenting the CEDIA "HDMI Update" seminar at three consecutive CEDIA Expos in Australia, as well as CEDIA events in Auckland, New Zealand, Beijing, China and Tokyo, Japan. We've also contributed extensively to the "HDMI Best Practices" for international publication, an initiative of CEDIA USA's Technology Council. We will continue to commit to such voluntary educational activities, especially as (dare I say) misleading or self-interested information does also continue to circulate, adding confusion.